INDOOR AIR QUALITY ASSESSMENT

Grafton Municipal Building/Intermediate School
30 Providence Road
Grafton, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of the Grafton Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Grafton Municipal Building/Intermediate School (GMB), Grafton, MA. Concerns about symptoms (e.g., dry itching eyes, headaches, fatigue and respiratory irritation) believed to be attributed to poor indoor air quality prompted this inspection.

On April 12, 2000, a visit was made to the building by Cory Holmes, Environmental Analyst for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an indoor air quality assessment. The GMB is a two-story brick building built in 1950. The Grafton Intermediate School occupies the second floor and portions of the first floor. The second floor consists of general classrooms, audio-visual room and main office. Located on the first floor are the art room, library/computer room, cafeteria and music rooms for the Intermediate School. The remainder of the first floor contains the town offices. Most of the building is carpeted and windows are openable throughout.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with a Mannix, TH Pen PTH 8708 Thermo-Hygrometer. Wind speed and direction were measured with a Davis, Wind Wizard, Wind Speed Indicator.

Results

The building has a student population of 450 and a staff of approximately 50 (including municipal staff). The tests were taken under normal operating conditions. Test results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in fifteen of the twenty-seven areas surveyed, which indicates ventilation problems in these areas of the building. Of note was classroom 31, which had levels of carbon dioxide in excess of 2000 ppm, indicating little or no air exchange. It is also important to note that a number of areas were sparsely populated or had open windows, which can greatly reduce carbon dioxide levels.

Fresh air in classrooms and most office space is supplied by a unit ventilator (univent) system. A univent draws fresh air from a vent on the exterior of the building and air from the classroom (called return air) through a vent in the base of the unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and expelled into the classroom through a fresh air diffuser located on the top of the unit. Univents were deactivated throughout the building by building maintenance the day of the assessment. Obstructions to airflow, such as paper and boxes stored on top of univent air diffusers as well as furniture and boxes in front of univent return vents were also noted in several areas (see Picture 1). In order for univents to provide fresh air as designed, univent air diffusers and return vents must remain free of obstructions. Importantly, these units must remain activated while the building is occupied.

Exhaust ventilation is provided by grilled, ducted wall vents. Exhaust vents were noted to be off or drawing weakly in a number of areas, which can indicate that exhaust ventilation was turned off, or that rooftop motors were not functioning. BEHA staff examined exhaust motors on the roof and found that the exhaust motors were operating. This would indicate that although motors were operating, they may not be functioning properly or that obstruction to airflow inside the ductwork may exist. Exhaust vents were also obstructed by bookcases, desks, chairs, file cabinets and other items (see Pictures 2 & 3). As with the univents, exhaust vents must remain free of obstructions to function properly.

The art room and Teacher's lounges each contained a wall-mounted local exhaust vent (see Picture 4). BEHA staff were unable to activate these fans via the pull chain mechanism. Without functioning exhaust ventilation in these rooms, heat and odors can build up, which can lead to complaints of poor indoor air quality. Maintenance personnel report that mechanical ventilation in the gymnasium was not functional and that it was on a repair list. In addition, mechanical ventilation in the cafeteria was operable, however, it was not activated during the assessment, which would account for the elevated level of carbon dioxide measured in the room during the lunch period (150 + occupants).

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of building occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each

room (BOCA, 1993, SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings were measured between 70^{o} F to 79^{o} F, which was close to the BEHA recommended range for comfort. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature complaints were reported to BEHA staff in a

number of areas. Temperature control is difficult without a properly functioning ventilation system.

The relative humidity measured in the building was within a range of 23 to 44 percent, which is below the BEHA recommended comfort range in most areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several rooms had water-damaged windowsills, which is evidence of historic or current water intrusion through improperly sealed windows. Windows appeared to be relatively new, which would indicate that water damage is the result of former leaks. Repeated water damage can result in mold colonization of window frames, curtains and items stored on or near windowsills. Once mold has colonized, these materials are difficult to clean and should be replaced.

A wall in the second floor prep room off of classrooms 22, showed signs of efflorescence (see Picture 5). Efflorescence is a characteristic sign of water damage to building materials, but it is not mold growth. As moisture penetrates and works its way through building materials, water-soluble compounds dissolve, creating a solution. As this solution moves to the surface, the water evaporates, leaving behind white, powdery mineral deposits. Water-damaged building materials, if wetted repeatedly, can be a medium for mold growth. A number of rooms had water-stained ceiling tiles (see Picture 6), which are evidence of historic roof or plumbing leaks. Water-damaged ceiling tiles can provide a

source of mold and mildew and should be replaced after a water leak is discovered and repaired.

Humidifiers were observed in several areas (see Picture 7) with standing water in them. BEHA staff removed the covers to several of these humidifiers and noted musty/mold-type odors and mold/scale growth lining the bottom and walls of the reservoir (see Picture 8). One of the units contained approximately 6 to 7 inches of standing water. It was reported to BEHA staff by the room occupant that this unit had not been activated for over a month. Standing water can become stagnant, provide a medium for bacterial and mold growth and be a source of unpleasant odors.

Several rooms had a number of plants. Plant soil and drip pans can serve as source of mold growth. Plants are also a source of pollen. In some areas flowering plants were noted near univent air diffusers (see Picture 1). Plant clippings and debris were noted inside the air diffuser in classroom 25 (see Picture 9). Plants should be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold.

Uninsulated copper pipes were noted in the Town Clerk's office over carpeting (see Picture 10). When warm, moist air passes over a surface that is colder than the air; water condensation can collect on the cold surface of the pipes. Over time, water droplets can form, which can then drip from a suspended surface. The cool temperature of the metal piping would make them prone to generating condensation. Dripping condensation can lead to mold growth on porous materials (i.e., carpeting). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth.

A number of classrooms have stuffed chairs, couches and sofas. Many of these appear to be stained, split open and in disrepair. As with carpeting, if old furniture and cushions become wet they can provide a medium for mold growth, which is difficult to clean.

Other Concerns

Several other conditions were noted during the assessment which can affect indoor air quality. Missing ceiling tiles were observed in several areas throughout the building. Missing ceiling tiles can provide a pathway for the movement of odors, fumes, dusts and vapors into occupied areas.

The AV room contains a lamination machine. No mechanical exhaust ventilation was noted in this area. Lamination machines can give off odors and excess heat. Without a functioning ventilation system, these odors can build up.

Abandoned water pipes were noted on the wall of the cafeteria (see Picture 11). If not in use, the traps to these pipes can dry out, allowing sewer gas to back up into occupied areas. Sewer gas can create nuisance odors and be irritating to certain individuals. These drains should be capped to prevent sewer gas back up.

Office areas contained window-mounted air conditioners. Portable air-conditioning units are normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can also be irritating to the eyes, nose and throat.

Also of note was the amount of materials stored inside classrooms. In classrooms and office areas throughout the building, items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a surface for dusts to accumulate. These items, (e.g. papers, folders, boxes, etc.) make it difficult for custodial staff to clean around these areas. Dust can be irritating to eyes, nose and respiratory tract. These items should be relocated and/or should be cleaned periodically to avoid excessive dust build up. In addition, a number of exhaust vents in classrooms were noted with accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize household dust particles.

Complaints of vehicle exhaust odors have been reported within the building. This has been attributed to the entrainment of vehicle exhaust into the building via the ventilation system from the employee parking lot (see Picture 12) and the idling of busses at the student drop-off area. Idling vehicles can result in the entrainment of vehicle exhaust into the building, which may, in turn, provide opportunities for exposure to compounds such as carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL., 1996).

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy independent of thermostat control.
2. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers building-wide.
3. Operate cafeteria ventilation system during hours of school operation to remove odors and to circulate air.
4. Restore exhaust ventilation in classrooms and office space. Examine rooftop exhaust motors for proper function; repair and replace parts as needed.
5. Remove all blockages from univents and exhaust ventilators to ensure adequate airflow.
6. Once both the fresh air supply and exhaust ventilation are functioning, the systems should be balanced by a ventilation engineer.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Repair/replace any water-stained ceiling tiles and wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial. Determine source of water entry through wall and eliminate.
9. Move plants away from univents in classrooms. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.
10. Clean humidifiers and dehumidifiers regularly and maintain as per the manufacturer's instructions to prevent microbial growth and/or unpleasant odors.
11. Replace missing ceiling tiles to prevent the egress of dirt, dust and particulate matter between rooms and floors.
12. Cap abandoned pipes in cafeteria to prevent sewer gas back up.
13. Consider insulating copper pipes and/or removing carpeting around pipes in the Town Clerk's Office to avoid condensation and the potential of mold growth on carpeting.
14. Re-activate or replace wall-mounted exhaust vent in art room and teacher's lounge to help circulate air and remove heat and odors.
15. Relocate student drop off area or have busses shut off engines after five minutes as required by Massachusetts General Laws 90:16A. To avoid entrainment of vehicle exhaust (see Picture 12), post signs in parking area instructing employees not to back in.
16. Change filters in window-mounted air conditioners as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.
17. Examine the feasibility of installing local exhaust ventilation for odor generating equipment in the AV room.
18. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

References

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OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R. 1910.1000 Table Z-1-A.

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

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Picture 1

Classroom Univent Obstructed by Various Items
Also Note Plant over Univent Air Diffuser

Picture 2

Exhaust Vent Obstructed by Table

Picture 3

Exhaust Vent Obstructed by File Cabinet

Picture 4

Non-Operable, Wall-mounted Local Exhaust Fan Noted in Teacher's Lounge (Similar Fan Noted in Art Room)

Picture 5

Efflorescence (i.e., Mineral Deposits) and Bubbled Paint Noted in the Classroom 22 Prep Room

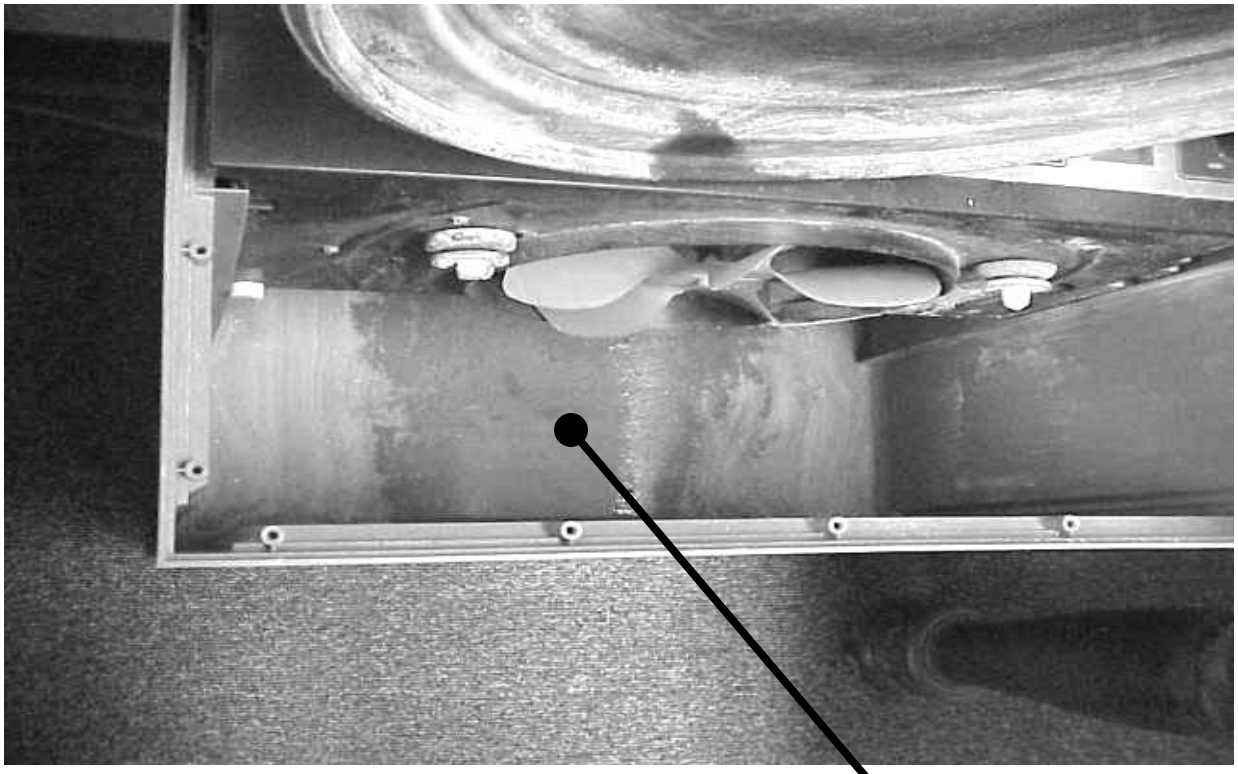
Picture 6

Water Damaged Ceiling Tiles

Picture 7

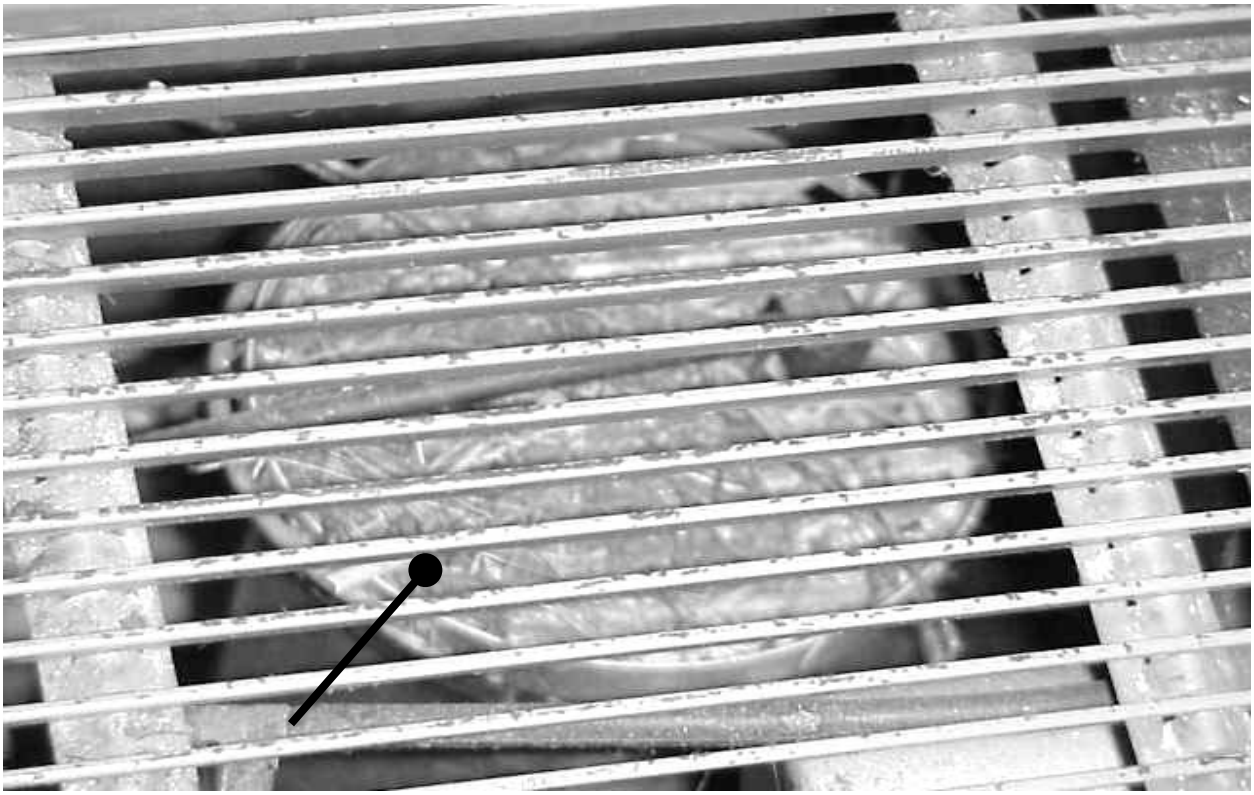
Example of Humidifier Utilized in the Grafton Municipal Building

Picture 8



Top View of Interior of Humidifier Note Unidentified Green Substance As Indicated by Dark Stain (Possible Mold Growth)

Picture 9



Plant Debris Noted in the Interior of Classroom Univent

Picture 10

Uninsulated Copper Pipes Noted in the Town Clerk's Office

Picture 11

Abandoned Pipes Noted in Cafeteria

Picture 12

Employee Parking Lot Note Univent Fresh Air Intake on Exterior of Building

TABLE 1

Indoor Air Test Results – Grafton Town Hall/Intermediate School, Grafton, MA – April 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	417	52	65					
Board of Health Office	758	77	30	4	yes	yes	yes	window open, univent off, window mounted air conditioner (a/c), 2 hanging plants
Classroom 28/29 (Double Classroom)	1839	77	44	45	yes	yes	yes	window open, univent off, exhaust off-partially blocked by table-back-draft
Classroom 30	1268	70	30	0	yes	yes	yes	univent and exhaust off
Classroom 33	1078	72	34	26	yes	yes	yes	univent and exhaust off, 4 plants-1 over univent, door open
2nd Floor Boy's Restroom							yes	
Classroom 27	1301	76	32	9	yes	yes	yes	univent and exhaust off, items on univent
Classroom 23	1132	72	33	20	yes	yes	yes	2 plants
AV Workroom 2					yes	no	no	laminator, 1 CT

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Grafton Town Hall/Intermediate School, Grafton, MA – April 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Board of Sewer Commissioner's Office	708	71	27	2	yes	yes	yes	window open, univent off-blocked, exhaust weak, window mounted a/c, 3 plants-flowering plant over univent
Cafeteria	1425	76	42	150+	yes	yes (3)	yes	univents and exhaust off, exhaust backdrafting, carpet, uncapped pipes
Teacher's Lounge	600	72	23	0	yes	no	no	local exhaust fan on wall-not operational
1st Floor Women's Restroom (near cafeteria)					yes	no	yes	exhaust off
Music Teacher's Office	1158	71	34	2	yes	no	no	1 CT, door open
Committee Meeting Room				0	yes	no	no	door open
Town Clerk	665	71	28	1	yes	no	no	window mounted a/c, chilling system un-insulated pipes over carpet
Vault					no	no	no	lots of paper/boxes/plans etc.-paper products, dusty
Veteran's Agent	666	70	28	2	yes	no	no	photocopier
Library/Computer Room	715	72	32	15+	yes	yes	yes	univent off, missing ceiling tile, window mounted a/c, exhaust on-very

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TABLE 3

Indoor Air Test Results – Grafton Town Hall/Intermediate School, Grafton, MA – April 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								weak, 22 computers
1st Floor Men's Restroom (near cafeteria)					yes		yes	exhaust off
Board of Assessor's	907	74	32	2	yes	yes	yes	univent off, humidifier-standing water-scale on bottom, mold odors, photocopier, 2 window mounted a/c, door open
Town Accountant	787	76	26	2	yes	yes	yes	univent off, window mounted a/c
Treasurer & Collection	784	75	29	3	yes	yes	yes	univent off, exhaust blocked by file cabinet, humidifier-standing water-reported last used approximately a month ago-odors, 2 window mounted a/c
Board of Selectmen	792	73	30	1	yes	yes	yes	univent off, 4 plants, water damaged windowsills/flaking paint, 2 window mounted a/c

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TABLE 4

Indoor Air Test Results – Grafton Town Hall/Intermediate School, Grafton, MA – April 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Planning Board	723	75	28	1	yes	yes	yes	univent off, 2 window mounted a/c, 10 plants, watering can-algae growth, plants over univent, photocopier, temperature complaints
Learning Center Back Room				0	yes	no	yes	exhaust off, passive vent in wall between Speech & Language Room/Learning Center
Speech & Language Room	1300	79	42	5	no	no	no	passive vent
Classroom 22	1184	76	38	17	yes	yes	yes	univent off, old couch-stained
Prep Room								efflorescence on wall-bubbled paint, 4 CT
Classroom 25	1421	79	42	22	yes	yes	yes	univent off, grass/plant debris in univent, feather duster
Classroom 24	1300	77	40	18	yes	yes	yes	exhaust blocked by table
Classroom 26	1180	74	30	8	yes	yes	yes	univent off-blocked, exhaust blocked
Classroom 31	2000+	78	36	18	yes	yes	yes	exhaust on-no draw, 2 plants

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CT = water-damaged ceiling tiles

Comfort Guidelines

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	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – Grafton Town Hall/Intermediate School, Grafton, MA – April 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Classroom 32	600	70	42	1	yes	yes	yes	univent off, exhaust on-no draw, window open
Classroom 35	483	72	32	18	yes	yes	yes	univent off, exhaust on-no draw, door open
Art Room	928	70	31	19	yes	yes (2)	yes	window open, univents off, wall mounted exhaust vent-not operable, room divided in half
Crawlspace								dirt floor, dry

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